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A BIOLOGICAL EVALUATION OF SPRUCE BEETLE ACTIVITY IN COYOTE GULCH DIXIE NATIONAL FOREST, ESCALANTE RANGER DISTRICT

by

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ABSTRACT

Since the mid 1990s', spruce beetle activity on the Dixie National Forest, Escalante Ranger District has been increasing. In the vicinity of Coyote Gulch on Boulder Top, spruce beetle related mortality was first detected in 1995 following a blowdown. At the request of Ecalante RD staff, stands in that area were surveyed in September-October, 1999 to determine their susceptibility for beetle attack and rate spruce beetle risk. Survey data were also used to evaluate the extent of beetle populations and trends. Upon completion of the survey, data were entered into a spreadsheet and analyzed using the **F**orest **In**sect and **Di**sease **T**ally (FINDIT) program. Results indicate that generally stands have low to moderate risk for spruce beetle outbreak, however, susceptible spruce occur in dense clumps throughout the area. Analysis also revealed that spruce beetle populations have exceeded endemic levels. These data are not sufficient to determine population trends, but, several units show an increase in the percentage of spruce attacked in recent years. Observations from other Forests in Utah, including the Fishlake and Manti-LaSal, indicate that building populations of beetles will probably continue to move through dense clumps until all suitable host trees have been killed. While beetle populations remain small, an aggressive approach to spruce beetle management would prevent future losses of spruce. The use of a density management program with the removal of infested spruce is recommended to ensure successful spruce beetle management. Trap trees, pheromone baited trees and funnel traps to capture emerging adults can be used in conjuction with density management treatments to help maintain a residual green tree component and reduce populations in areas not conducive to harvesting operations.

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Introduction

The spruce beetle, *Dendroctonus rufipennis* Kirby (Engelm.) is the most important biotic disturbance agent affecting post-fire, spruce-fir forests in the Intermountain region (Holsten et al. 1991, Veblen et al. 1994, Jenkins et al. 1996). Since the mid 1990s', spruce beetle activity on the Dixie National Forest, Escalante Ranger District has been increasing. Aerial detection surveys conducted in 1994 showed no evidence of spruce mortality associated with beetles, yet by 1995, widespread pockets of up to 20 dead trees were detected on Boulder Top. In the vicnity of Coyote Gulch, the rise in activity likely resulted from an extensive blowdown that occurred prior to spruce beetle flight spring of 1995. As of 1998, approximately 6,000 Engelmann spruce spruce (*Picea engelmannii* Perry) had been killed.

Engelmann spruce serves as the principle host for spruce beetle, although they infrequently attack blue spruce (*Picea pungens* Engelm.), and during epidemics may kill lodgepole pine (*Pinus contorta* Dougl. ex Loud) and subalpine fir (*Abies lasiocarpa* (Hooker) Nutt.) (Miller 1970, Schmid and Frye 1977). Outbreaks can potentially cause extensive spruce mortality adversely affecting watershed, timber, wildlife, aesthetics and recreational resources. Mortality caused by spruce beetles also increases fuel loads and over time results in a high fire hazard (Schmid and Frye 1977, Jenkins et al. 1996).

Endemic populations of spruce beetles generally reside in downed, green host material. Local populations can build to epidemic levels following logging activity, blow down or avalanche disturbances that create an abundance of suitable host material. As competition for food intensifies, beetles may then attack live, standing trees.

Spruce beetle flight usually begins in early June and ends by mid-August with peak flight occuring in July. During the flight period, colonizing female beetles locate suitable host trees and bore into the inner bark. These females emit aggregation pheromones that attract other females and males to the host tree. Once mated, females begin to construct elongated "J-shaped" egg galleries depositing eggs in niches along alternate sides of the gallery. Eggs are generally oblong, pearly white and up to 1 mm long. Incubation lasts 3-4 weeks before an egg hatches into a stout, white legless larva with a prominent rust-colored head capsule. Larvae feed in the phloem creating mines perpendicular to the egg gallery. Larval feeding effectively girdles the tree eventually causing death.

The typical life cycle of a spruce beetle lasts two years (Furniss and Carolin 1977), although certain proportions of the population could have a one year life cycle (Matt Hansen, *pers. comm.*). Seasonal temperatures appear to have an important role in the timing and length of beetle development with one year life cycles evident following mild fall conditions. In Utah, a two year life cycle is most common. During the summer and fall after attack, larvae can develop up to the fourth instar before entering diapause to overwinter. Larvae generally resume development in the spring with pupation occurring in the early summer. Spruce beetles reach maturity prior to the second winter. New adults are dark brown to black with reddish brown elytra. With age, older adults turn uniformily black. Beetles overwinter a second time as adults and emerge the following year to attack host material.

Spruce beetles typically attack large, overmature spruce killing trees individually, or in small groups creating canopy gaps (Veblen et al.1991). During a severe outbreak, beetles may attack

spruce down to 4 inches dbh, although brood may not develop in small diameter trees. Removal of overstory trees results in a modification of stand structure and species composition through a reduction in average spruce diameter, height, basal area, and age. The lack of bare, mineral soil following beetle disturbance may also deter the establishment of spruce seedlings (White 1970). Stands affected by past beetle outbreak generally have a scarcity of spruce older than 140 years and non-host species typically become stand dominants (Veblen et al.1994, Jenkins et al. 1996).

During the summer of 1999, John Anhold, Entomologist, FHP Ogden Field Office, visited the Coyote Gulch site to assess the level of spruce beetle activity. A biological evaluaton was requested by the Escalante Ranger District staff. Stands were surveyed in September-October, 1999 to determine stand susceptibility for beetle attack and to assess spruce beetle risk. Survey data were also used to evaluate the extent of beetle populations and trends.
This report describes the methods used to conduct the survey and provides the results of our biological evaluation. Recommendations and management alternatives are also discussed to reduce potential beetle impacts and improve forest health.

Methods

443 variable plots were systematically distributed in spruce-fir stands in the Coyote Gulch area for the purpose of data collection. Plots were spaced at 10 chain (1 chain = 66 feet) intervals along parallel transects located 10 chains apart to ensure adequate coverage of the area. From plot center, a 10 basal area factor prism was used to determine sample trees. Only trees > 5 inches diameter at breast height (dbh) were tallied. Individual tree data collected included species, status (live or dead) and dbh. Each sample spruce was then examined for evidence of spruce beetle infestation and given a code for the year and type of attack (mass or strip).

Data Analysis

Upon completion of the survey, data was entered into a spreadsheet and analyzed using the **F**orest **In**sect and **Di**sease **T**ally (FINDIT) program (Bentz 1999, *In Prep.*) Surveyed units were comprised of stands having various mixtures of aspen (*Populus tremuloides* Michx.), Engelmann spruce and subalpine fir and for analyses grouped according to structure, species composition, history and management objectives. The attached map of the area (Appendix 1) shows the deliniation of the 13 resultant Coyote Gulch (CG) groups. The following statistics were calculated for each group:

1. Total live basal area (ft^2/ac)
2. Average live quadratic mean diameter (QMD) for spruce
3. Average dbh of spruce > 10 inches
4. Percentage of each tree species
5. Percentage of basal area (BA) comprised of each tree species
6. Percentage of basal area killed by spruce beetle in 1999, 1998 and mortality older than 1998
7. Percentage of total basal area killed by spruce beetle

Stand susceptibility was assessed using a risk rating system developed by Schmid and Frye (1976). Factors used in this system for calculating risk include physiographic location

determined from site indices, average QMD of live spruce > 10 inches dbh, stand basal area and proportion of spruce in the canopy.

Results

Table 1 summarizes data used for the determination of risk and developing general recommendations. As this table indicates, aspen was the primary component in the majority of groups surveyed ranging from 37 to 71% of the total number of trees per acre. Although Engelmann spruce comprised approximately one third of all trees, it represented the largest percentage of mean basal area in most groups. Subalpine fir was a minor component and < 1% of Douglas-fir was present in group CG 13.

Total live basal areas were within ranges generally below levels of high risk for spruce beetles. These data, however, do not reflect the occurrence of dense spruce clumps throughout stands and individual plots located in clumps often had basal areas exceeding 150 ft^2 per acre. In addition to locally high densities, average spruce diameters and percentages of spruce > 10 inches in each group allude to the presence of sufficient numbers of large trees suitable for attack and brood production in much of the area. Based upon the conventional spruce beetle risk rating model, the majority of groups rated low to moderate. Survey results, however, indicate that a small percentage to 28 % of spruce had been currently attacked by spruce beetle throughout the management area. Plots within each group having current and older attacked trees are circled on the map. Groups CG 4, 9 and 10 had no plots with attacked trees, however, attacked spruce were observed between plots. Although results show that 28% of spruce in CG 8 were currently attacked, this value seems unreasonably high as these units had previously been harvested. Error in transcribing unit boundaries on the survey map most likely explains this inflated value. Excluding this group, CG 11 had the greatest percentage of current attacks with 25% of the spruce affected, while 16 % of spruce in CG 1 had current attacks. Comparing the diameters of spruce in each attack category suggests that beetles initially selected spruce with larger diameters for colonization and have subsequently began colonizing smaller diameter classes.

Discussion

Although stand conditions are not conducive to supporting an outbreak, these data indicate that spruce beetle populations have exceeded endemic levels. Under endemic conditions, populations are generally regarded as having no effect on the complexion of the biotic community in which they occur (Graham 1963). These data are not sufficient to determine population trends, but, several groups show a slight increase in the percentage of spruce attacked in recent years. Locally heavy infestations have occurred with beetle related mortality resulting in 4-39 % of total spruce volume loss. Observations from other Forests in Utah, including the Fishlake and Manti-LaSal, indicate that beetles will probably continue to move through dense clumps until all suitable host trees have been killed.

Risk ratings are generally used to determine a stand's susceptibility to spruce beetle infestation. Because the insect is already present in a number of the stands surveyed, stand risk can be used to determine where additional losses could occur in adjacent uninfested stands. Most of the future mortality will occur in stands rated as moderate.

Based on the results of this survey, observations of Forest Service personnel and trends shown on aerial insect detection surveys, spruce beetle populations in the Coyote Gulch area will likely continue to increase with beetles spreading into uninfested units and neighboring stands.

Recommendations

To reduce susceptibility of stands to spruce beetle attack and to reduce the build-up of local populations, we recommend you consider preventative actions for spruce beetle management within the next few years. Several conventional alternatives for effective management exist (Schmid and Frye 1977). These include:

A. Silvicultural Treatments

1. In units where beetles pose a threat and susceptible spruce comprise less than the recommended percentage of basal area to be harvested, remove all infested spruce throughout the entire management area. In those units, or portions of units having a high percentage of large diameter spruce occurring in clumps with densities exceeding 100 ft^2, remove spruce with diameters exceeding 12 inches dbh leaving an average diameter of 10 inches dbh and reduce basal area of clumps to 80-100 ft^2 per acre. Spacing left between residual trees should increase as spruce diameters increase to sufficiently open up the canopy and expose boles to sunlight. Selection in clumps should favor non-host trees. Groups with a majority of units meeting these criteria would include CG 1, 3, 4, 7, 9, 10, 11, 12 and 13. While achieving desired spruce beetle management objectives, other benefits of this treatment would include deriving some commercial value from harvested timber, creating greater species diversity where dense clumps of spruce occur and treating fewer acres. Undesirable consequences of this treatment would include loss of large diameter overstory spruce, some site impacts, probable damage to residual trees and increased potential for windthrow. Slash wuld require careful attention with appropriate measures for treatment and the prompt removal of any infested material.

2. In units where susceptible spruce comprise more than the recommended percentage of basal area to be harvested, the following three silvicultural options are possible:

    a. Remove all infested and susceptible trees > 12 inches dbh from the entire management area leaving average spruce diameters of 10 inches. This would accomplish spruce beetle management while deriving some commercial value. Both beneficial and adverse impacts to wildlife species might occur depending on the selection of any alternative. Undesirable consequences of this treatment would include more extensive site impacts, visual impacts, damage to regeneration, loss of structural diversity, an increased potential for windthrow and creating heavy fuel loads.

b. Generally remove recommended basal area in attacked and susceptible trees throughout the management area. This alternative would not afford complete suppression with significant loss of large diameter spruce highly probable in the long term. Fuel loads would also increase over time, in addition to dead trees providing a source of inoculum for the build-up of root disease fungi on the site. Some commercial values would be derived, however, and certain wildlife species would benefit from the presence of infested trees, snags, downed woody material and the diversity created.

c. Leave units uncut. This option would not provide spruce beetle protection and likely result in the loss of all basal area comprised of large diameter sppruce should the current level of beetle activity continue. Surviving trees would consist of non host and small diameter spruce leaving salvage as the only commercial option. Other costs might include the loss of viable, natural seed sources of spruce requiring artificial regeneration of the site. Extensive mortality would result in the build-up of heavy fuel loads and the potential for unnaturally large and intense wildfires given an ignition source and appropriate fire weather conditions. Mortality might also provide a source of inoculum for root diseases (Shaw and Kile 1991). Over time, successive wildlife species would benefit from the presence of infested material, snags and down material, in addition to changes in species composition and structural diversity. In the absence of catastrophic fires, the site would retain nutrient resources essential for sustained productivity.

B. *Trap Trees*

Trap trees may be used in units with isolated pockets and/or low populations of beetles to effectively reduce local populations. Trap trees may also be utilized in stands having a large component of non host species, or in areas where silvicultural treatments may not prove feasible. Trap trees are generally large, green trees with diameters exceeding 16 inches dbh felled prior to the onset of flight to capture colonizing beetles. Infested trap trees should be removed or developing brood killed by burning the same year trees are attacked. To attract beetles, trap trees should be felled in cool moist locations retaining limbs to provide shading and support off the ground for greater surface colonization. Until sufficiently infested, trap trees should also remain unbucked to prevent desication. Careful consideration should be given trap trees felled in close proximity to uninfested stands to avoid the risk of attracting beetles to those stands. In groups CG 1, 2, 3 and 5 where beetle populations appear static, one trap tree is recommended per 4-5 infested standing trees. In groups CG 6, 7, 11, 12 and 13 where it appears that populations are increasing, one trap tree per 2-3 infested standing trees is recommended. In centers of spruce beetle activity, clustering trap trees has proven effective. Two to four trees are felled one chain apart to concentrate attacks.

C. *Pheromones*

Pheromone baits stapled on the north side of standing, green spruce are effective in attracting beetles and inducing attack. Secondary attraction to the host tree often develops and populations become concentrated in manageable areas. Cluster baiting appears to maximize attraction. In infested clumps of 10-12 spruce, baits are attached to three trees one half to one chain apart. Once infested, baited trees are then removed or the brood destroyed in the same manner as trap trees during the year of attack. Effective baits usually consist of Frontalin combined with alpha-pinene. Bait or trap tree strategies are most effective with pre-outbreak populations of the insect or where isolated infestations occur.

D. *Funnel Traps*

This technique uses funnel traps baited with a chemical pheromone to attract beetles. This is the least effective means of reducing beetle numbers, however, when used in conjuction with trap or baited trees this technique can help reduce populations. Like baited trees there will be spillover where green residual spruce are attacked. Funnel traps are deployed similar to baits in clusters of up to three traps within the infested pocket. One funnel trap for every 10-12 infested trees. Hang funnels on non host or dead spruce to minimize spillover.

E. *Chemicals*

Chemicals sprayed on the boles of susceptible trees prior to spruce beetle flight can provide effective short term protection from attack. To maximize their effectiveness, individual trees require treatment with application of the chemical up to a bole height of 40-50 feet. All bole surfaces and the root collar must be sprayed completely to ensure thorough coverage of all bark crevices. This often becomes difficult and expensive over large areas. For these reasons, their use has been generally restricted to protecting high value trees and would not be a recommended strategy in the Coyote Gulch area.

Conclusions

Spruce beetle activity in the vicinity of Coyote Gulch has been steadily increasing since 1995 with current populations exceeding endemic levels. Although most units generally rate low to moderate according to conventional spruce beetle risk rating systems, susceptible spruce grow in dense clumps throughout many stands and a high potential for outbreak exists in these areas with additional loss of large diameter spruce likely. Currently, spruce beetle activity remains small and implementation of an aggressive management approach would minimize potential future mortality.

An aggressive approach would include the techniques mentioned above including the removal of all infested spruce where possible. The use of a density management program with the removal of infested spruce is recommended to ensure successful spruce beetle management. Trap trees, pheromone baited trees and funnel traps to capture emerging adults can be used in conjunction

with density management treatments to help maintain a residual green tree component and reduce populations in areas not conducive to harvesting operations.

Density management treatments, however, require a multi-year commitment with 3-5 years of management to reduce spruce beetle populations to endemic levels. Because of the explosive nature of spruce beetle populations no treatment guarantees complete protection once an outbreak develops, however, employing this strategy provides the best option.

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Table 1. Coyote gulch spruce beetle survey summary table.

Unit	tot tpa*	% AS	% ES	% AF	% DF	tot live BA	% ES BA	% ES >10"	av dbh of ES >10"	% ES attacked	% cur mean dbh	% last yr mean dbh	% older mean dbh	% BFV lost	ESB risk rating!
CG 1	327	58	24	18	0	104	42	41	16	16	5 (14)	6 (11)	6 (16)	19	M
CG 2	247	56	29	15	0	86	33	45	14	8	2 (14)	2 (19)	3 (20)	33	L-L/M
CG 3	231	46	38	16	0	94	51	53	15	4	1 (17)	<1 (19)	3 (21)	4	L/M-M
CG 4	260	71	16	14	0	99	30	56	16	0	0	0	0	0	L/M-M
CG 5	171	45	40	15	0	75	39	53	14	3	1 (15)	<1 (23)	2 (22)	14	L/M-M
CG 6	171	46	33	21	0	74	38	59	15	3	2 (18)	<1 (15)	2 (18)	22	L/M-M
CG 7	201	45	37	18	0	81	42	51	16	9	5 (16)	<1 (19)	3 (19)	27	L/M-M
CG 8	173	37	52	12	0	86	43	62	13	28	24 (10)	4 (15)	0	29	L/M-M
CG 9	237	55	40	5	0	88	37	30	15	0	0	0	0	0	L-L/M
CG 10	415	66	20	14	0	103	36	26	15	0	0	0	0	0	L/M-M
CG 11	201	51	34	15	0	75	53	65	16	25	8 (15)	2 (14)	14 (17)	39	L/M -M
CG 12	301	64	24	12	0	108	37	43	16	5	5 (17)	<1 (23)	<1 (14)	16	L/M-M
CG 13	262	45	26	29	<1	100	41	51	16	5	3 (19)	<1 (20)	<1 (20)	14	L–L/M

*tpa = trees per acre; AS = aspen; ES = Engelmann spruce; AF = subalpine fir; DF = Douglas-fir; BA = basal area; dbh = diameter at breast height; BFV = board foot volume; ESB = Engelmann spruce beetle.

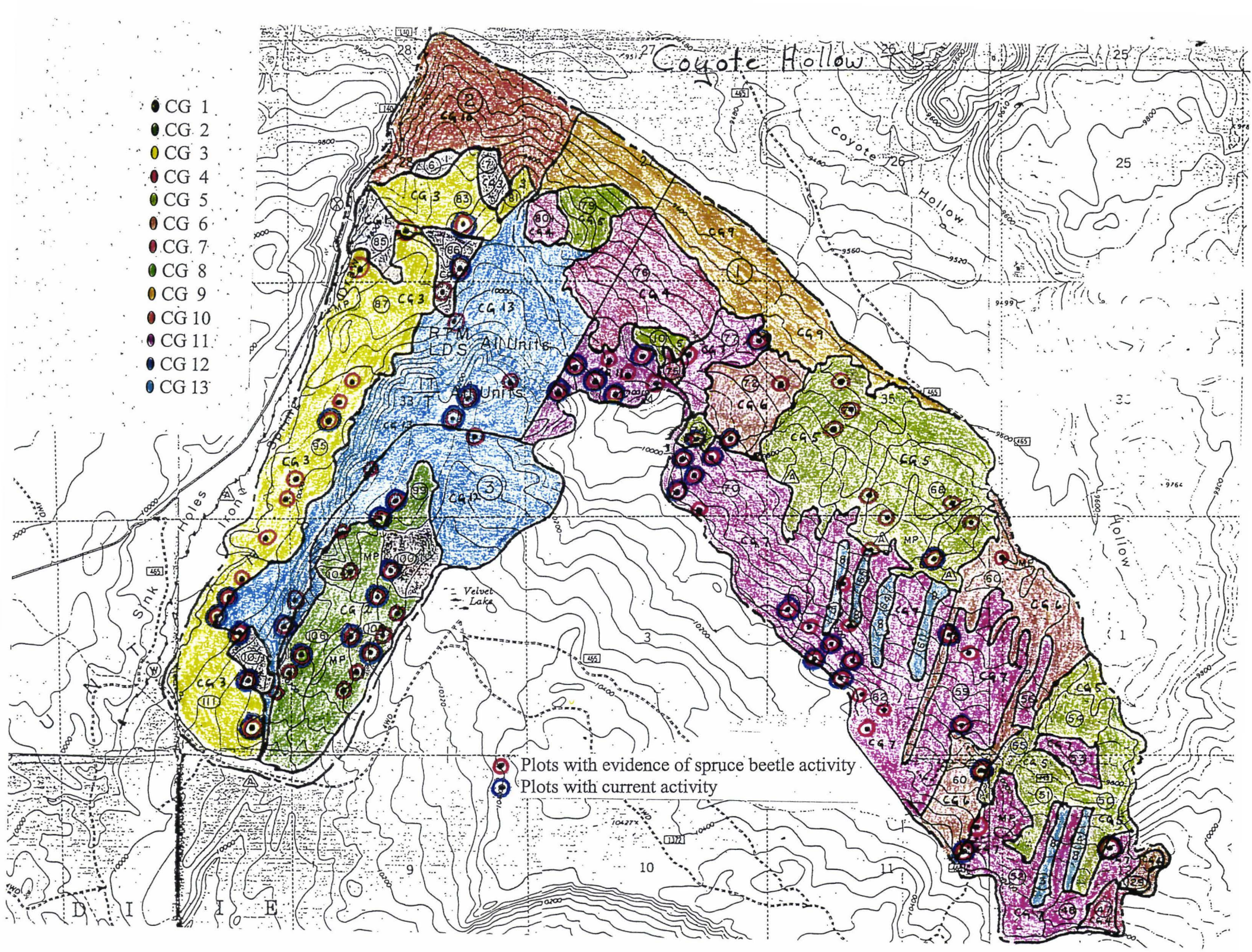
! spruce beetle rating (Schmid and Frye 1977); L = low; M = moderate; L/M = low to moderate.

Appendix 2. Risk categories for potential spruce beetle outbreaks for each stand characteristic.

Risk category[1]	Physiographic location	Average diameter of live spruce above 10 inches d.b.h.	Basal area	Proportion of spruce in canopy
		Inches d.b.h.	*Ft^2*	*Percent*
High (3)	Spruce on well-drained sites in creek bottoms	> 16	> 150	> 65
Medium (2)	Spruce on sites with site index of 80 to 120	12-16	100-150	50-65
Low (1)	Spruce on sites with site index of 40 to 80	< 12	<100	<50

[1]Number in parentheses indicates arbitrary value to be used in calculating stand priority, and is used only for convenience.

Stand Risk Value	**Potential Outbreak Rating**
11- 12	High
10	High/Intermediate
7-9	Medium
6	Intermediate/Low
4-5	Low


CG 1
CG 2
CG 3
CG 4
CG 5
CG 6
CG 7
CG 8
CG 9
CG 10
CG 11
CG 12
CG 13
Coyote Hollow
Coyote Hollow
RTM
LDS
All Units
All Units
Velvet Lake
Holes
Ikona
Spring
Sink
Plots with evidence of spruce beetle activity
Plots with current activity

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